5.3.3 Semiconductor

In a semiconductor, the energy gap between valance band and conduction band is very small. It is shown in figure 5.4. A semiconductor material is an element with four valence electrons and whose electrical properties lie in between that of insulators and conductors.

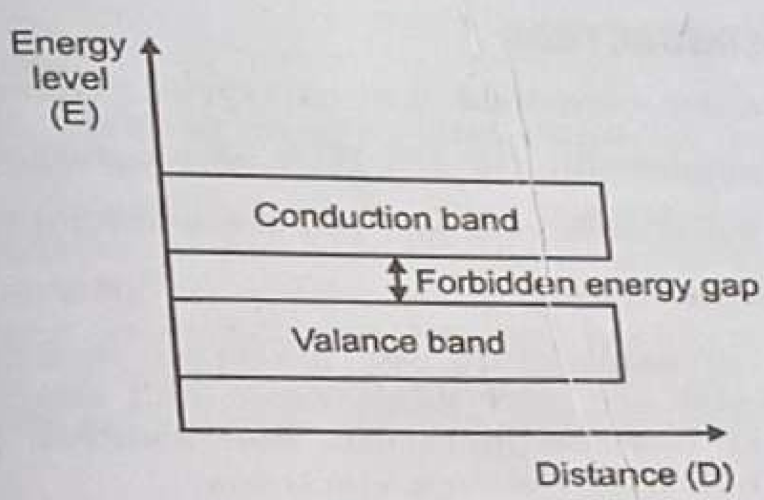

Figure 5.4

5.4 TYPES OF SEMICONDUCTORS

Semiconductors are classified into two-types. These are

1) Intrinsic semiconductor (or) Pure semiconductor

2) Extrinsic semiconductor (or) Impure semiconductor

Intrinsic semiconductor

The pure form of semiconductor material is known as intrinsic semiconductor. Examples are pure germanium and silicon. In an intrinsic semiconductor, even at room temperature, hole-electron pairs are created; there being as many holes as the free electrons.

Extrinsic semiconductor

In an intrinsic semiconductor, at room temperature current conduction is very less. To increase the conductivity of the semiconductor, some suitable impurity or doping agent is added. The process of adding impurities to a semiconductor is known as 'doping'. This impure form of semiconductor is called extrinsic semiconductor.

Comparison between Intrinsic semiconductor and Extrinsic semiconductor

Sl	Intrinsic semiconductor	Extrinsic semiconductor
1.	It is a pure form of semiconductor.	It is an impure form of semiconductor.
2.	Number of electrons and holes are equal.	Number of electrons and holes are not equal because of doping.
3.	Conductivity is poor.	Conductivity is improved by adding impurity.

5.5 TYPES OF EXTRINSIC SEMICONDUCTOR

Depending upon the type of impurity added, extrinsic semiconductor are classified in two types such as,

1) N type semiconductor

2) P type semiconductor

N type semiconductor

When a pentavalent impurity is added to an intrinsic semiconductor, N type semiconductor is obtained. Example for pentavalent impurity are arsenic and antimony. The arsenic or antimony are called as donor impurities, because it donating an electron to Ge or Si crystal. However, the number of free electrons provided by donor impurity far exceeds the number of holes in a semiconductor thus it is called as 'N' type semiconductor. For N type semiconductor, the electrons are majority carrier and holes are minority carriers.

P type semiconductor

When a small amount of trivalent impurity is added to a pure semiconductor, P type semiconductor is formed. Example for the trivalent impurity are boron, gallium, indium etc. Thus the addition of trivalent impurity provides a large number of holes in the semiconductor. Such a holes can accept electrons hence the trivalent impurity also known as acceptor impurity. In this semiconductor, more holes are created due to the addition of trivalent impurity, hence it is named as P type semiconductor. In this type of semiconductor, holes are majority carriers and electrons are minority carriers.

Comparison between N type and P type semiconductor

Sl	N type semiconductor	P type semiconductor
1.	N type semiconductor is created by adding pentavalent impurity into pure Silicon or Ge.	P type semiconductor is created by adding trivalent impurity into pure semiconductor.
2.	Doping agent as Arsenic, Antimony etc.	Doping agent as gallium, Indiam etc.
3.	Here, majority carrier are electrons and minority carriers are holes.	Here, majority carriers are holes and minority carriers are electrons.

5.6 THEORY OF PN JUNCTION

- A junction is formed between a sample of 'P' type semiconductor and a sample of 'N' type semiconductor joined together then this device is called the PN junction.
- The formation of PN junction is also called as Diode, because it has two electrodes one for P region named as Anode and the other for 'N' region named as Cathode.

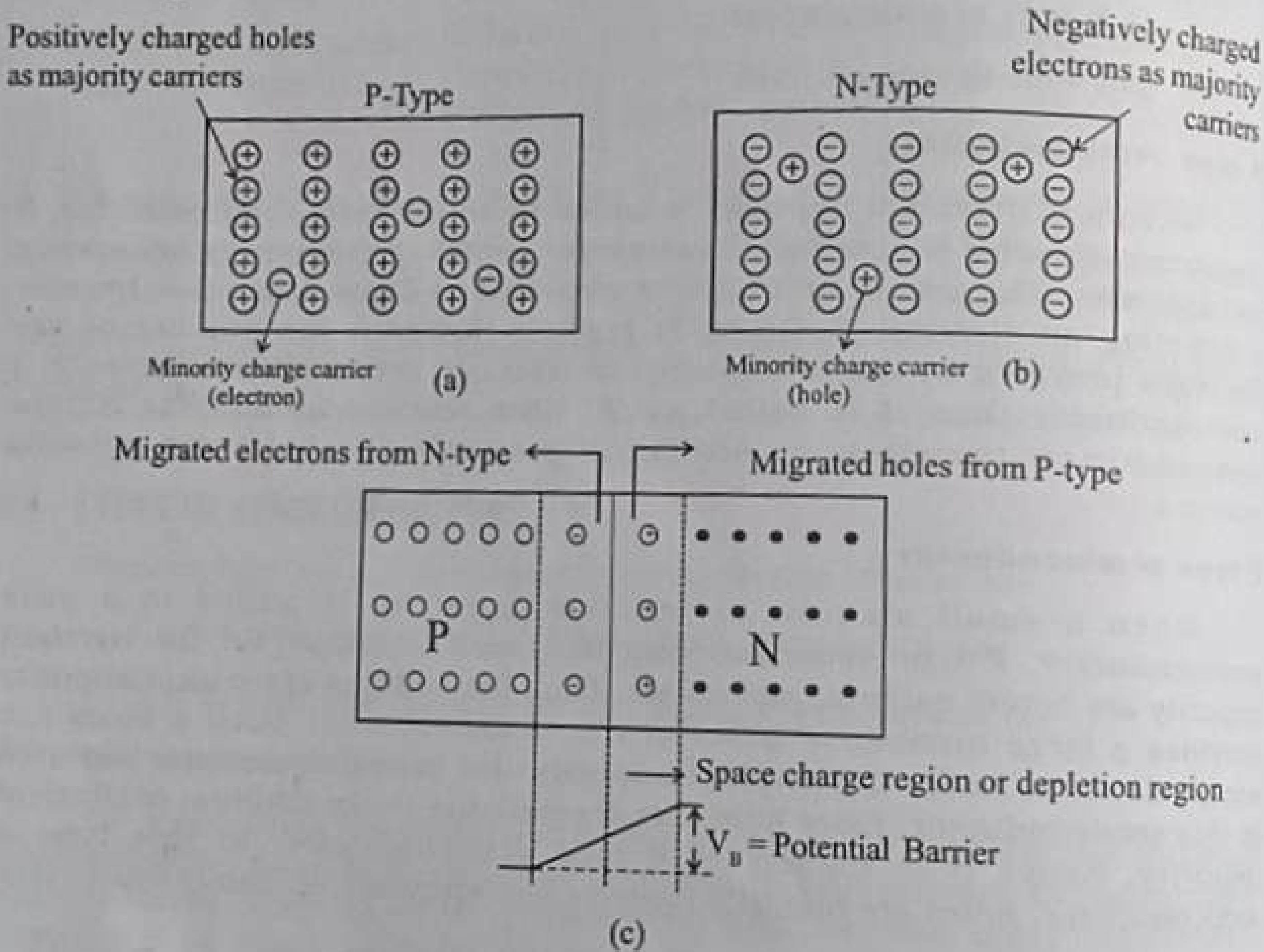

Figure 5.5: Operation of PN junction

- The N type semiconductor has high concentration of free electrons while 'P' type semiconductor has high concentration of holes as shown in figure 5.5(a). At the junction there is a tendency for the free electrons to move towards the 'P' side and holes to the ' N' side and vice versa. This process is known as Diffusion. The diffusion is the process by which charge carrier move from high concentration area to low concentration area.
- When a free electrons diffusing from 'n' side into 'p' side recombine with the holes and leaves a negatively charged immobile ions near the junction of 'p' side. Similarly holes diffusing from 'p' side into 'n' side recombine with electrons and leaves a positively charged immobile ions near the junction of 'n' side.
- After certain extent the immobile positive ions deposited across the 'n' region prevents further charge carrier diffusion from 'p' region into 'n' regions, similarly the immobile negative ions deposited across the 'n' regions into 'p' region. These immobile ions forms a region, it is known as depletion region. i.e., the region over which all the mobile or free charge carrier are depleted. The region is also known as Space charge region or Charge free region because there is no free charge carriers are available for conduction.
- The existence of these immobile ions develops the potential difference across the junction, this potential acts as barrier for further conduction between the junction. Thus, this potential is named as barrier potential or cut in voltage of semiconductor diode. The value of barrier potential is 0.3V for germanium diodes and 0.7V for silicon diodes.

Junction Voltage or Barrier Voltage

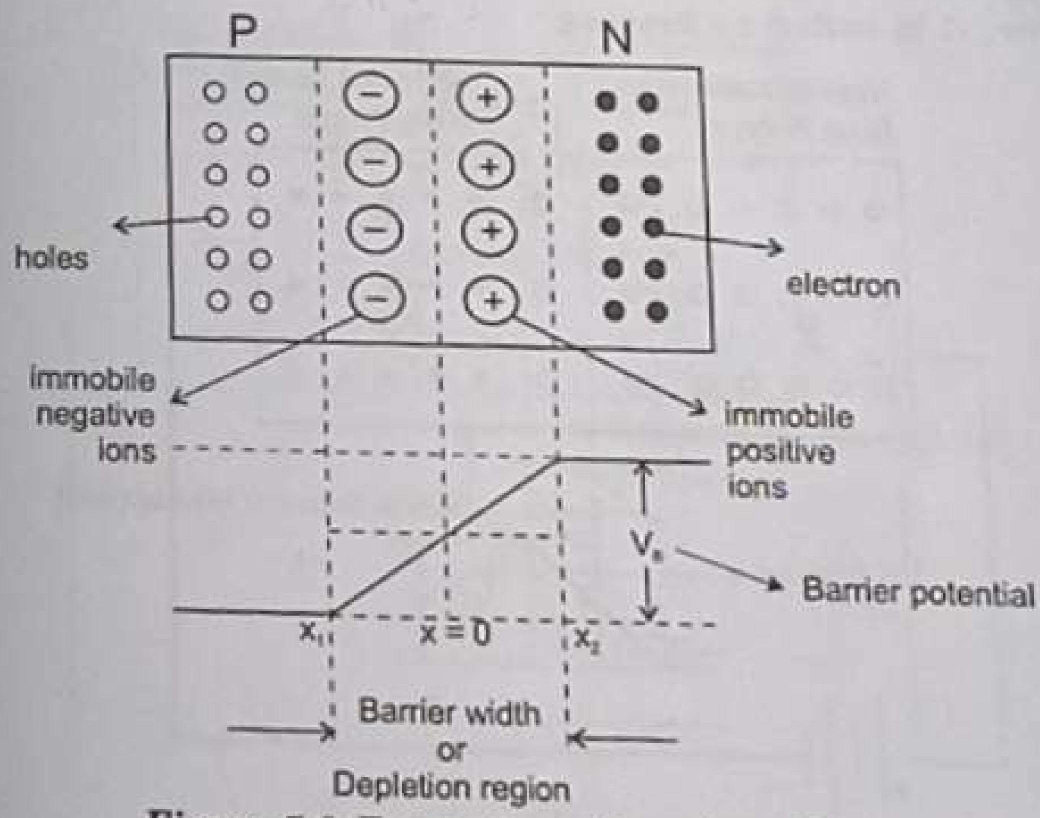

Figure 5.6: Formation of barrier voltage

When the depletion layer is formed there are negative immobile ions in P-type semiconductor and positive immobile ions in N-type semiconductor as shown in figure 5.6 due to this charge separation, a voltage V_B is developed across the junction under equilibrium condition. This voltage is known as **"junction potential or barrier potential"**.

It is clear from the figure 5.6 that the potential barrier V_B set up in this manner gives rise to an electric field. This electric field prevents the respective majority carriers from crossing the barrier region. The potential barrier is in the order of 0.1V to 0.3V for Ge and 0.7V to 1.1V for silicon.

The barrier potential of a PN junction depends upon three factors namely density, charge and temperature. For a given PN junction the first two factor are constant. Thus making the value of V_B dependent only on temperature. It has been observed that both germanium and silicon diodes decrease their barrier potential by 2mV/°C.

5.6.1 *Operation of a PN Junction*

In order to understand the working of the PN junction diode, we shall consider the effect of forward bias and reverse bias across the P-N junction

i) Forward Bias

- In an unbiased PN junction, there is no flow of current. A PN junction connected to an external voltage source is called as **"biased PN junction"**. By this biasing the width of depletion region is controlled which results in control of its resistance and current flow is possible.
- When an external voltage is applied to the P-N junction, in such a way that it cancels the potential barrier and permits the current flow, it is called as **biasing**.

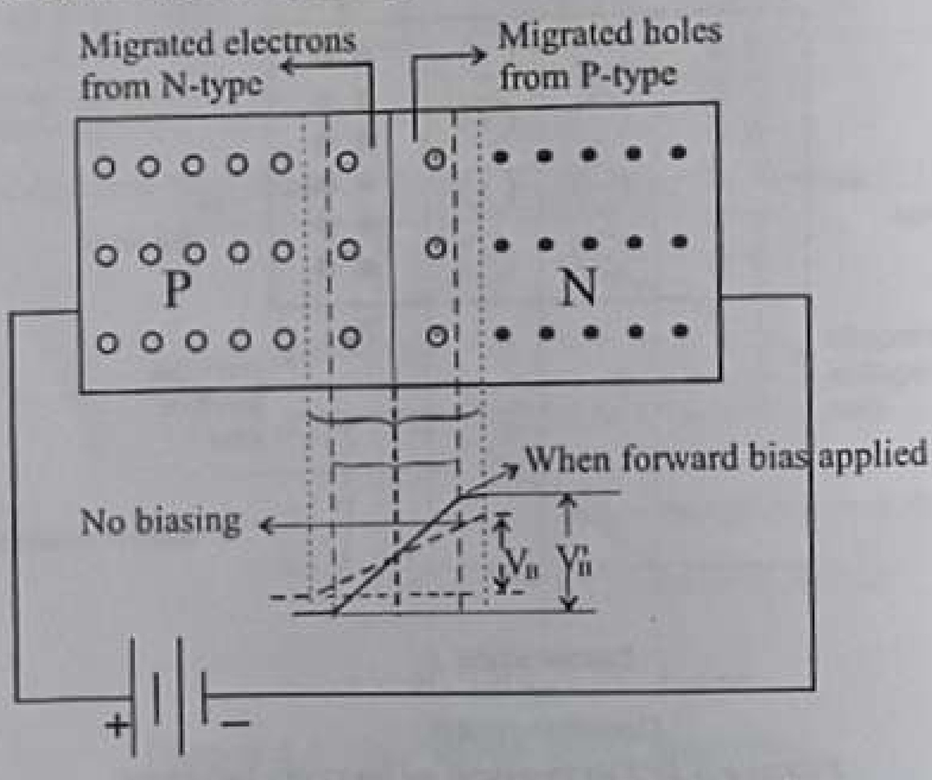

Figure 5.7: Forward biased PN junction

- When the positive terminal of a battery is connected with P-type semiconductor and the negative terminal is connected with N-type semiconductor as shown in the figure 5.7 provides the **forward bias to PN junction**.
- The applied forward potential establishes an electric field opposite to the potential barrier. Therefore the potential barrier is reduced. As the potential barrier is very small (0.3v for Ge and 0.7v for Si), a small forward voltage is sufficient to completely eliminate the barrier potential, thus the junction resistance becomes zero.
- In other words, the applied positive potential repels the holes in the 'P' region so that the holes move towards the junction and applied negative potential repels the electrons in the 'N' region towards the junction results in depletion region starts decreasing. When the applied potential is more than the internal barrier potential then the depletion region completely disappear, thus the junction resistance becomes zero.
- Once the potential barrier is eliminated by a forward voltage, junction establishes the low resistance path for the entire circuit, thus a current flows in the circuit, it is called as **forward current**.

ii) **Reverse Bias**

- When an external voltage is applied to P-N junction in such a way that it increases the potential barrier then it is called as **"reverse bias"**. For reverse bias, the negative terminal is connected to P type semiconductor and positive terminal is connected to N type semiconductor as shown in figure 5.8.

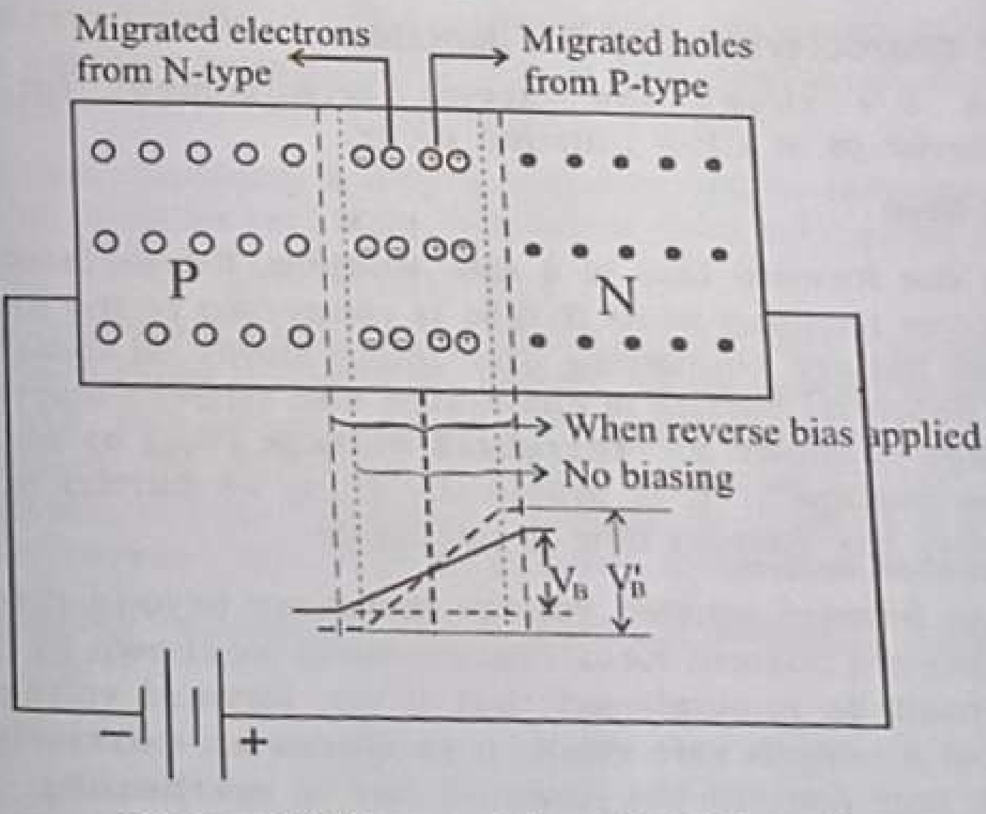

Figure 5.8: Reverse biased P-N Junction

- When reverse bias voltage is applied to the junction, all the majority carriers of 'P' region are attached towards the negative terminal of the battery and the majority carriers of the N region attached towards the positive terminal of the battery, hence the depletion region increases.
- The applied reverse voltage establishes an electric field which acts in the same direction of the potential barrier. Therefore, the resultant field at the junction is strengthened and the barrier width is increased. This increased potential barrier prevents the flow of charges carriers across the junction, results in a high resistance path is established.
- From the above discussion we conclude that when a P-N junction is forward biased, it has a low resistance path and hence current flows in the circuit due to the majority carriers. On the other hand, when it is reverse biased, it has high resistance path and no current flows in the circuit. This process cannot continue indefinitely because after certain extent the junction break down occurs. As a result a small amount of current flows through it due to minority carriers. This current is known as **"reverse saturation current"**.
- Thus P-N junction diode is a unilateral device which offers a low resistance when forward biased and behaves like an insulator when reverse biased.

The holes traveling from 'p' region to 'n' region and electrons travelling from 'n' region to 'p' region constitute the conventional currents in the same direction namely from 'p' region to 'n' region. So the resultant current is the summation of the two currents.

5.6.2 *V-I Characteristics of P-N Junction*

Figure 5.9 shows the circuit arrangement for drawing the V-I Characteristics of a P-N junction diode.

i) Forward Bias

- For the forward bias of a P-N junction, P-type is connected to the positive terminal while N-type is connected to the negative terminal of the battery. On varying this voltage slowly, at some forward voltage the potential barrier is eliminated and current starts flowing. This voltage is known as **"thershold voltage (V_{Th}) or cut in voltage** or **knee voltage"**. It is practically same as barrier voltage V_B. For $V < V_{Th}$ the current flow is negligible.
- As the forward applied voltage increases beyond threshold voltage, the forward current rises exponentially as shown in the figure 5.17. It should be remembered that if the forward voltage is increased beyond a certain safe value, it produces an extremely large current which may destroy the junction due to overheating.

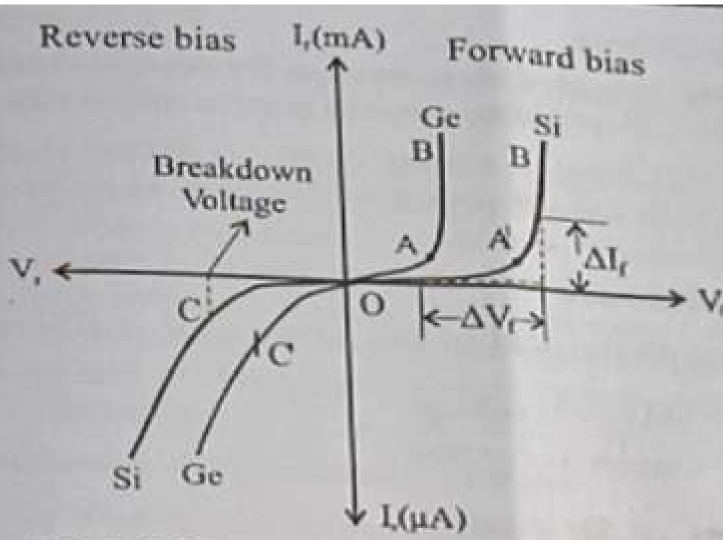

Figure 5.9: V-I Characteristics of PN junction diode

- In portion OA or OA' (non linear operating region) even if the large variation in applied voltage small variation in the current flowing through the diode because of the depletion region occurs. At point 'A', $V_f = V_{th} = V_B$ hence the depletion region disappears result in which the current linearly increases in portion AB or AB'. This portion is known as **linear operating region** of diode.

  The forward resistance of the diode is obtained from the slope of the curve

$$R_f = \frac{\Delta V_f}{\Delta I_f}$$

ii) **Reverse Bias**

- For the reverse bias of P-N junction, P-type semiconductor is connected to the negative terminal and N-type semiconductor is connected to the positive terminal of the battery.
- Under this condition, a strong depletion region is formed across the junction, it offers very high resistance, thus very small current flows oc and oc' shown in figure 5.9.
- In this case the junction resistance becomes very high and practically no current flows through the circuit. If the reverse voltage is further increased, the kinetic energy of the electrons become so high that they knock out electrons from semiconductor atoms. At this stage breakdown of junction occurs results in there is a sudden rise of reverse current. This current is known as **reverse saturation current.**

  The reverse resistance of the diode is obtained from the slope of the curve

$$R_r = \frac{\Delta V_r}{\Delta I_r}.$$

5.6.4 *Applications of PN diode*

1. As switches
2. As rectifiers
3. Power supplies
4. Clippers and clampers
5. Digital systems
6. Communication systems

5.7 ZENER DIODE

- In a general purpose PN diode the doping is light, as a result of this the breakdown voltage is high. If a P and N region are heavily doped then the breakdown voltage can be reduced.
- When the doping is heavy, even the reverse voltage is low, the electricfield at barrier will be so strong thus the electrons in the covalent bands can break away from the bonds. This effect is known as **zener effect**.
- A diode which exhibits the zener effect is called a **zener diode**. Hence it is defined as a reverse biased heavily doped PN junction diode which operates in breakdown region. The zener diodes have been designed to operate at voltages ranging from a few volts to several hundred volts.
- **Zener breakdown** occurs in junctions which is heavily doped and have narrow depletion layers. The breakdown voltage sets up a very strong electric field. This field is strong enough to break or rupture the covalent bonds thereby generating electron hole pairs.
- Even a small reverse voltage is capable of producing large number of current carrier, When a zener diode is operated in the breakdown region care must be taken to see that the power dissipation across the junction is within the power rating of the diode otherwise heavy current flowing through the diode may destroy it.

Equivalent circuit of Zener diode

The schematic symbol and its equivalent circuit is shown in figure 5.22 It is similar to that of normal diode except the line representing cathode is bent at both end is shown in figure 5.10.

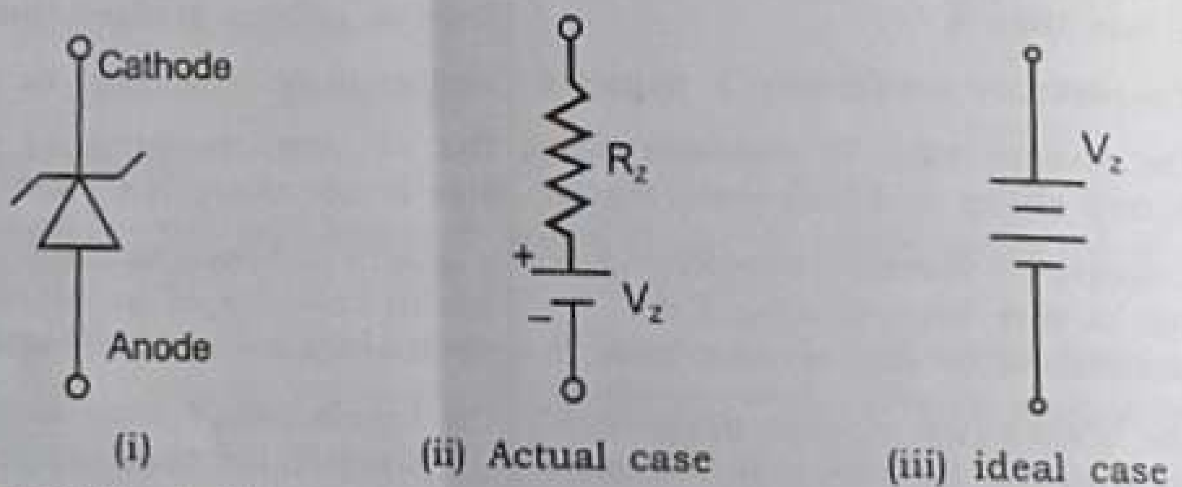

Figure 5.10: Symbolic representation of zener diode and its equivalent circuit

When the reverse bias voltage across of Zener diode exceeds the breakdown voltage V_z, the current increases very sharply. It means that voltage across Zener diode is constant at V_z even though the current through it changes. Therefore in breakdown region, a Zener diode may be represented by a battery of voltage V_z in series with the Zener resistance as shown in figure 5.10.

V-I Characteristics of zener diode

Figure 5.11 shows the V-I characteristics of zener diode.

The forward characteristics of a zener diode is similar to that of a P-N Junction diode. The reverse characteristics of zener diode is obtained as follows.

- The reverse current that is present at the origin and the knee of the curve is due to the reverse leakage current due to the minority carriers. This current is specified by stating its value at 80% of the zener voltage V_Z.

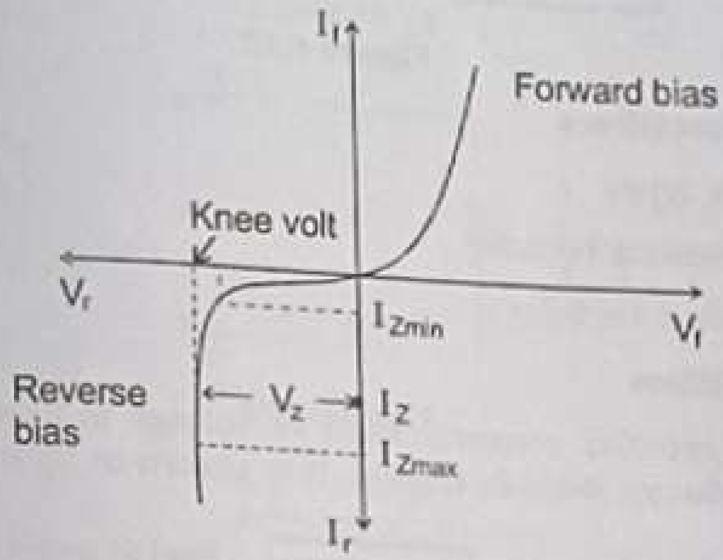

Figure 5.11: VI Characteristics of Zener diode

- As the reverse voltage is gradually increased, the breakdown occurs at the knee and the current increases rapidly. To control this current a suitable external resistance has to be used. The maximum permissible value of the current is denoted by I_{zmax}. The minimum usable current is I_{zmin}.

- The voltage across the terminals of the diode for a current I_z which is the approximate midpoint of the linear range of the reverse characteristics in called the **zener voltage V_Z**. At the knee point, the breakdown voltage remains constant between I_{zmax} and I_{zmin}. This ability of a diode is called regulating ability and is an important feature of a zener diode.

Application of Zener Diode

It can be used a) as voltage regulators b) as peak clippers c) for reshaping waveforms d) for meter protection against damage from accidental application of excessive voltage.

5.8 RECTIFIERS

Many electronic devices need d.c voltage sources. It is not very convenient to rely on batteries for such voltages. Circuits which are used to convert a.c voltage to dc voltage are called rectifiers.

Actually, a rectifier convert the ac voltage to a unidirectinal (pulsating) voltage. When this voltage (or current) is passes through a filter, we get a voltage (or current) of more nearly constant value. It is shown in figure 5.12.

Figure 5.12

Classification of rectifiers

There are two types

1. Uncontrolled rectifier
2. Controlled rectifier

Uncontrolled rectifiers

Uncontrolled rectifier converts fixed ac voltage to fixed dc output voltage. Here, the semiconductor devices diodes. It is shown in figure 5.13.

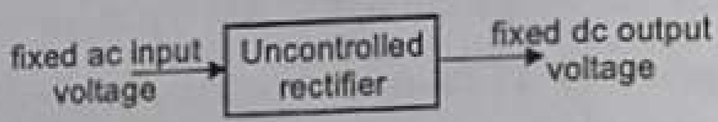

Figure 5.13

Controlled rectifiers

A controlled rectifier converts fixed ac voltage to a variable dc voltage. Here, the semiconductor devices are SCRs.

Types of uncontrolled rectifiers

There are three types:

i) Half-wave rectifier,

ii) Centre tapped full wave rectifier,

iii) Full wave bridge rectifier

5.8.1 *Half-wave Rectifier*

Figure 5.14 shows single phase half-wave rectifier circuit.

It consists of transformer, diode and load resistance. Here diode act as a switch i.e., under forward biased condition, it is a closed switch and reverse biased condition, it is a open switch. The transformer used to step down the input voltage.

The sinusoidal ac voltage is fed to transformer primary winding. The voltage across the secondary winding is $v_s = V_m \sin \omega t$. 'V_m' is the maximum value of the input voltage.

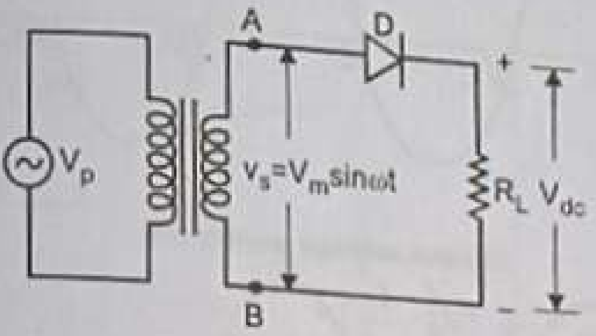

Figure 5.14

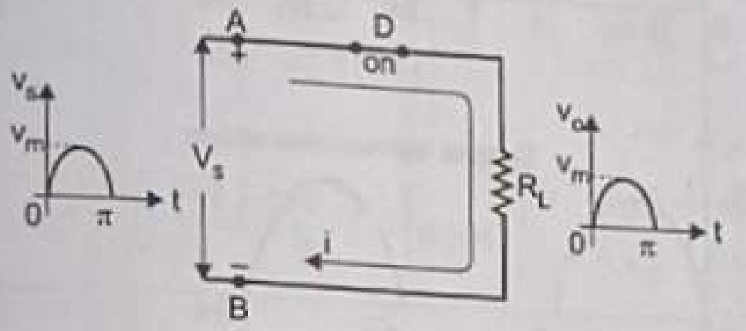

Figure 5.15

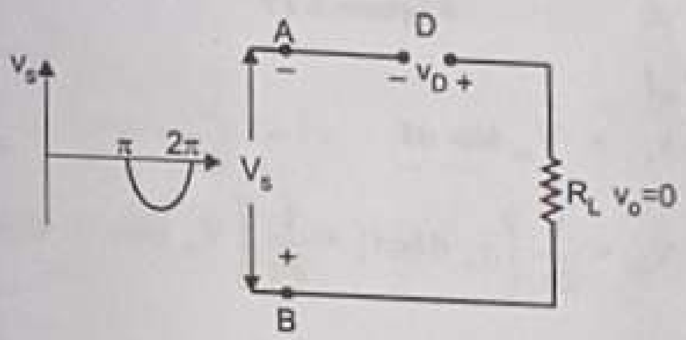

Figure 5.16

Operation

During positive half cycle of the input voltage (0 to π), the point A is positive with respect to point B. During this period, the diode becomes forward biased and it act as a closed switch. The entire positive input voltage is applied across the load. The current path is A – D – R_L – B. It is shown in figure 5.15.

During negative half cycle (π to 2π) of the input voltage, the point 'B' is positive with respect to point 'A'. During this period, diode becomes reverse biased. Then it act as a open switch. There is no output voltage across load. The entire negative half cycle input voltage appears across the diode. There is no current in the load. It is shown in figure 5.16.

The input and output waveforms are shown in figure 5.17.

From this wave forms, the output voltage is not a steady state dc but only a pulsating d.c. Here, we are using only half-cycle of the input wave. That is why it is called a half-wave rectifier.

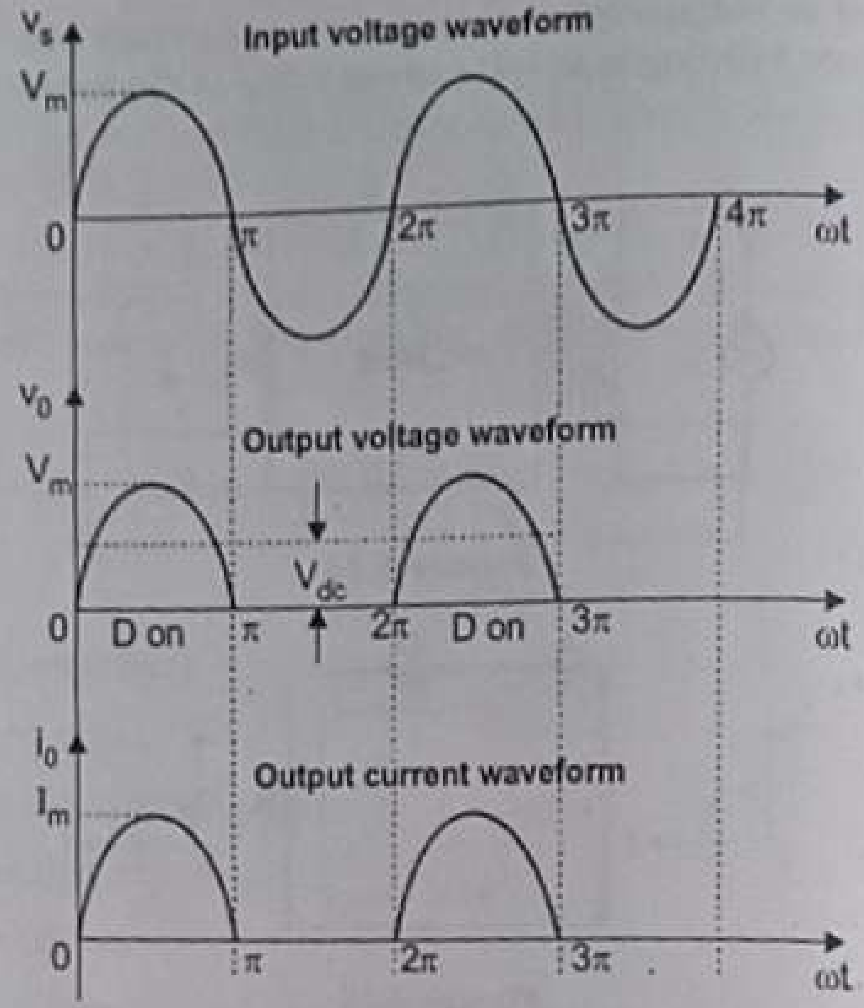

Figure 5.17

DC output voltage (V_{dc})

Input voltage $v_s = V_m \sin \omega t$

$$V_{dc} = \frac{1}{2\pi}\int_0^{2\pi} v_s \, d(\omega t) = \frac{1}{2\pi}\int_0^{2\pi} V_m \sin \omega t \cdot d(\omega t)$$

$$= \frac{1}{2\pi}\left[\int_0^{\pi} V_m \sin \omega t \cdot d(\omega t) - \int_{\pi}^{2\pi} 0 \, d(\omega t)\right]$$

$$= \frac{1}{2\pi}\int_0^{\pi} V_m \sin \omega t \cdot d(\omega t) = \frac{V_m}{2\pi}\left[-\cos \omega t\right]_0^{\pi} = \frac{V_m}{2\pi}\left[+1-(-1)\right]$$

$$\boxed{V_{dc} = \frac{V_m}{\pi}}$$

where V_m = maximum (or) peak value of input voltage

$= \sqrt{2}\, V_s$

DC output current (I_{dc})

$$\boxed{I_{dc} = \frac{V_{dc}}{R_L}} = \frac{V_m}{\pi R_L}$$

$$\boxed{I_{dc} = \frac{I_m}{\pi}}$$

Rms output voltage (V_{orms})

$$V_{orms} = \left[\frac{1}{T}\int_0^T v_o^2 \, d(\omega t)\right]^{1/2} = \left[\frac{1}{2\pi}\int_0^\pi V_m^2 \sin^2 \omega t \cdot d(\omega t)\right]^{1/2}$$

$$= \left[\frac{V_m^2}{2\pi}\int_0^\pi \sin^2 \omega t \, d(\omega t)\right]^{1/2}$$

$$= \left[\frac{V_m^2}{2\pi}\int_0^\pi \left(\frac{1-\cos 2\omega t}{2}\right) d(\omega t)\right]^{1/2} = \left[\frac{V_m^2}{4\pi} \times \pi\right]^{1/2}$$

$$\boxed{V_{orms} = \frac{V_m}{2}}$$

RMS load current (I_{orms})

$$I_{orms} = \frac{V_{orms}}{R_L} = \frac{V_m}{2R_L} = \frac{I_m}{2}$$

$$\boxed{I_{orms} = \frac{I_m}{2}}$$

DC output power (P_{dc})

$$P_{dc} = I_{dc}^2 R_L = \frac{V_m^2}{\pi^2} R_L$$

AC input power P_{in}

$$P_{in} = I_{orms}^2 R_L = \frac{I_m^2}{4} \cdot R_L$$

Rectifier efficiency

$$\eta = \frac{P_{dc}}{P_{in}} = \frac{\frac{I_m^2}{\pi^2} R_L}{\frac{I_m^2}{4} \cdot R_L} = \frac{4}{\pi^2} \times 100$$

$$\boxed{\eta = 40.6\%}$$

Advantages

1. Simple circuit.
2. Low cost.

Disadvantages

1. Low rectification efficiency.
2. Low TUF.
3. High ripple factor.
4. DC saturation of transformer core, which results when the current in the secondary side of transformer flows in the same direction, leads to hysteresis losses and harmonics in the output.

5.8.2 Centre Tapped Fullwave Rectifier

Figure 5.18 shows centre tapped fullwave rectifier circuit. It consists of two diodes, one centre-tap transformer and load resistor. By centre tapping, the impedance of the two halves of windings are equal. Thus the voltages in the two halves are 180° out of phase or when point A of secondary is maximum positive value, C is at maximum negative value.

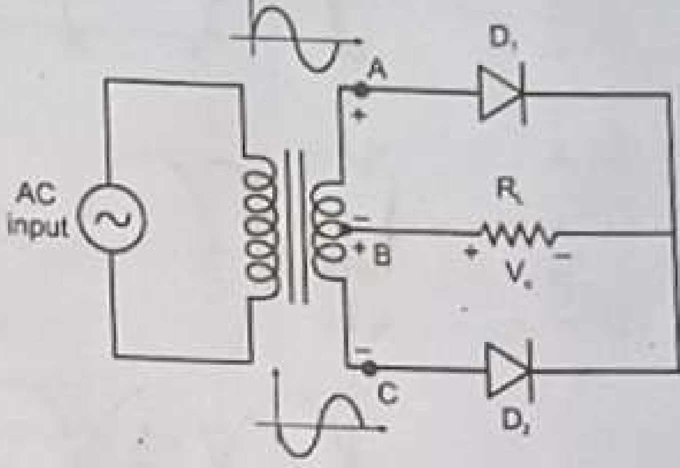

Figure 5.18

Operation

When an ac input is applied to primary winding of transformer, as per the principle of transformer theory, it transferred to the secondary winding without changing the supply frequency.

During the positive half cycle of the input voltage, the terminel A is more positive than terminal 'C' thus diode D_1 becomes more forward biased than diode D_2.

Thus diode D_1 act as a closed switch and diode D_2 act as a open switch. The current path is A → D_1 → R_L → B. Therefore, we can get positive output voltage across load. It is shown in figure 5.19.

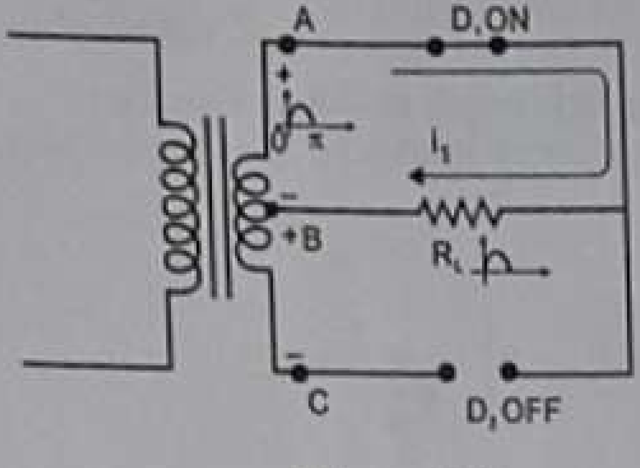

Figure 5.19

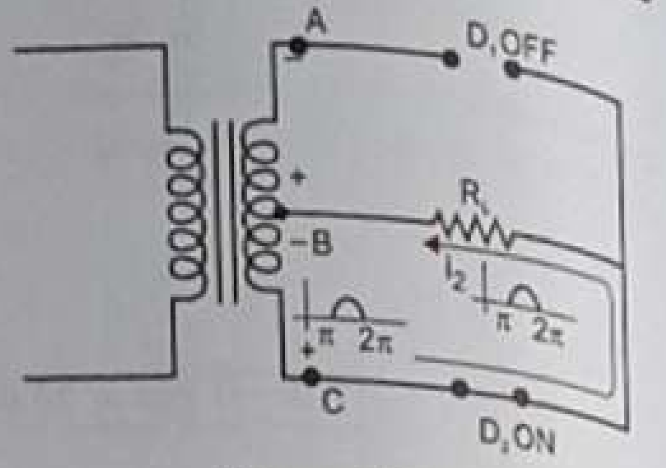

Figure 5.20

During the negative half cycle of the input voltage, the terminal C is more positive than terminal 'A', thus diode D_2 becomes more forward biased than diode D_1. Thus diode D_2 acts as a closed switch and diode D_1 acts as a open switch.

Then the current path is C - D_2 – R_L – B. Here, we can get positive output voltage across load. It is shown in figure 5.20.

The input and output waveforms are shown in figure 5.21.

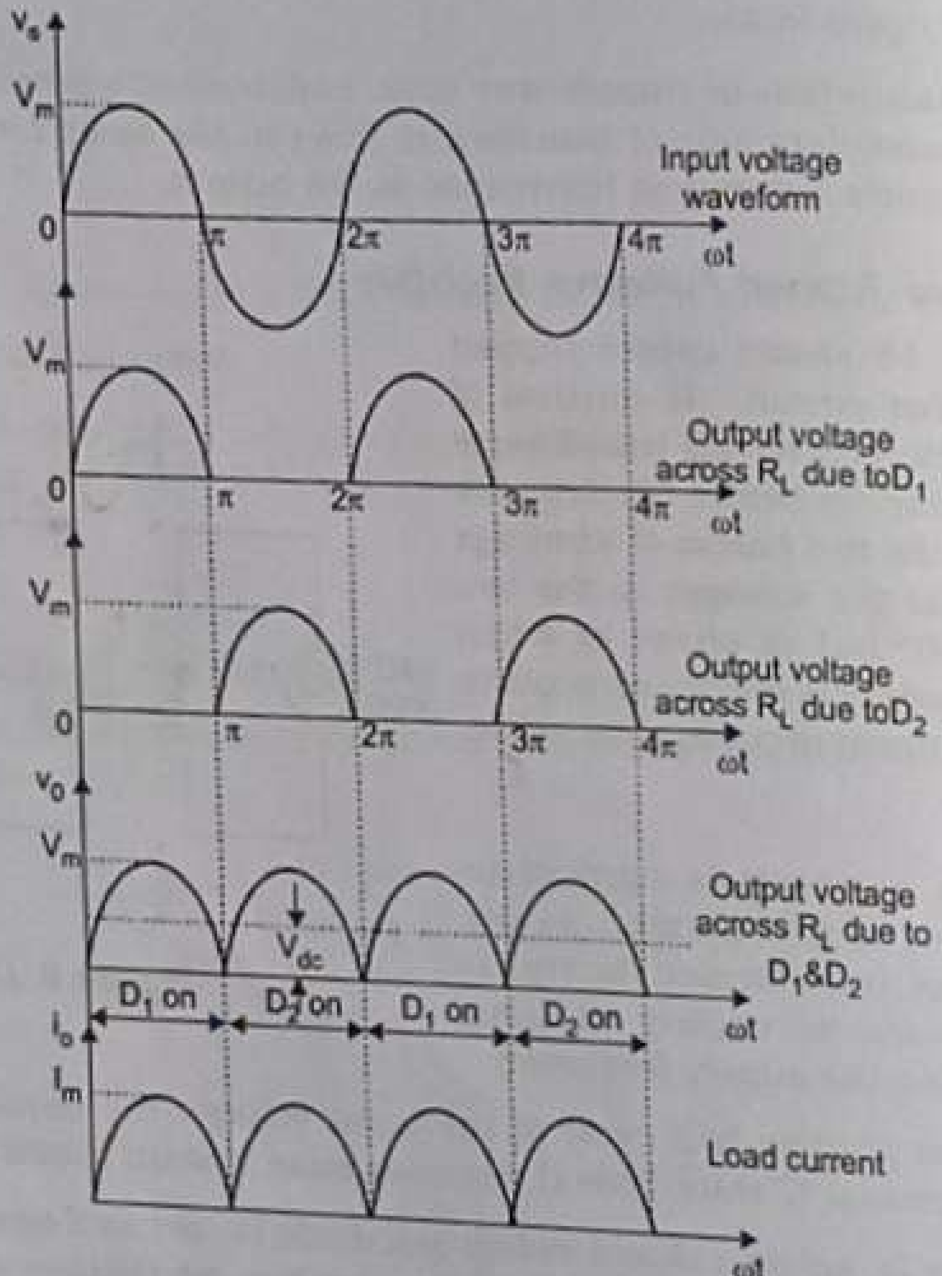

Figure 5.21

The ripple frequency on a single phase fullwave rectifier is twice the supply frequency i.e., $2f$. If the supply frequency is 50Hz, ripple frequency of this rectifier is $2 \times 50 = 100$ Hz.

Average output voltage (V_{dc})

Input voltage $v_s = V_m \sin \omega t$

Input current $i_s = I_m \sin \omega t$

Dc or average voltage is of same form in the two halves of the ac cycle hence it is calculated for half cycle of input only.

$$V_{dc} = \frac{1}{T}\int_0^T V_s \, d(\omega t)$$

$$= \frac{1}{\pi}\int_0^\pi V_m \sin \omega t \cdot d(\omega t) = \frac{V_m}{\pi}\int_0^\pi \sin \omega t \cdot d(\omega t)$$

$$= \frac{V_m}{\pi}[-\cos \omega t]_0^\pi = \frac{V_m}{\pi}[-\cos\pi - (-\cos 0)]$$

$$= \frac{V_m}{\pi}[+1+1]$$

$$\boxed{V_{dc} = \frac{2V_m}{\pi}}$$

Average output current (I_{dc})

$$I_{dc} = \frac{1}{T}\int_0^T i_s \, d(\omega t) = \frac{1}{\pi}\int_0^\pi I_m \sin \omega t \cdot d(\omega t)$$

$$\boxed{I_{dc} = \frac{2I_m}{\pi}} \quad \text{or} \quad \boxed{I_{dc} = \frac{V_{dc}}{R}}$$

RMS output voltage (V_{orms})

$$V_{orms} = \left[\frac{1}{\pi}\int_0^\pi v_s^2 \, d(\omega t)\right]^{1/2} = \left[\frac{1}{\pi}\int_0^\pi V_m^2 \sin^2 \omega t \cdot d(\omega t)\right]^{1/2}$$

$$= \left[\frac{V_m^2}{\pi}\int_0^\pi \sin^2 \omega t \cdot d(\omega t)\right]^{1/2} = \left[\frac{V_m^2}{\pi}\int_0^\pi \left(\frac{1-\cos 2\omega t}{2}\right) d(\omega t)\right]^{1/2}$$

$$= \left[\frac{V_m^2}{\pi}\left(\omega t - \frac{\sin 2\omega t}{2}\right)_0^\pi\right]^{1/2}$$

$$\boxed{V_{orms} = \frac{V_m}{\sqrt{2}}}$$

RMS load current (I_{orms})

$$I_{orms} = \frac{V_{orms}}{R_L} = \frac{V_m}{\sqrt{2}\,R_L} = \frac{I_m}{\sqrt{2}}$$

DC output power (P_{dc})

$$P_{dc} = I_{dc}^2\,R_L = \frac{4\,I_m^2}{\pi}R_L$$

AC input power (P_{in})

$$P_{in} = I_{orms}^2\,R_L = \frac{I_m^2}{2}R_L$$

Efficiency

Rectifier efficiency $\eta = \frac{P_{dc}}{P_{in}} \times 100$

$$= \frac{\frac{4I_m^2}{\pi}R_L}{\frac{I_m^2}{2}R_L} \times 100 = \frac{8}{\pi^2} \times 100$$

$$\boxed{\eta = 81\%}$$

Ripple factor

The ripple factor of full wave rectifier is defined as the ratio of ac or rms value of ripple component to average or dc component present in the output.

$$RF = \frac{I_{rrms}}{I_{dc}} = \frac{\sqrt{I_{orms}^2 - I_{dc}^2}}{I_{dc}^2}$$

$$= \sqrt{\left(\frac{I_{orms}}{I_{dc}}\right) - 1}$$

The form factor is given by

$$FF = \frac{I_{orms}}{I_{dc}} = \frac{I_m/\sqrt{2}}{\frac{2I_m}{\pi}} = \frac{\pi}{\sqrt{2}} = 1.11$$

Hence ripple factor

$$RF = \sqrt{1.11^2 - 1}$$

$$\boxed{RF = 0.48}$$

5.8.3 Full wave Bridge Rectifier

The full wave rectifier uses a centre tap transformer, whose secondary voltage is twice the output voltage. The diode must also have ratings of twice the peak inverse voltage of that used in half wave rectifier circuits. In the bridge rectifier circuit, the centre-tap transformer is eliminated and also the PIV rating of the diodes is not so large.

Construction

Figure 5.22 shows the circuit diagram of bridge rectifier circuit. It consists of transformer, 4 diodes and a load resistor.

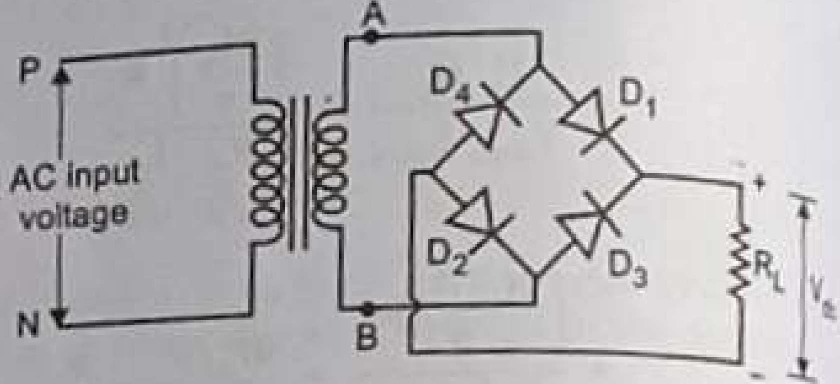

Figure 5.22

Operation

During the positive half cycle of the input voltage, the terminal 'A' is positive with respect to B. Thus diodes D_1 and D_2 are forward biases and diodes D_3 and D_4 reverse biased. Then the current flows through diode D_1, load R_L and through diode D_2 back to the negative polarity of transformer secondary. It is shown in figure 5.23. The entire positive input voltage is applied across the load.

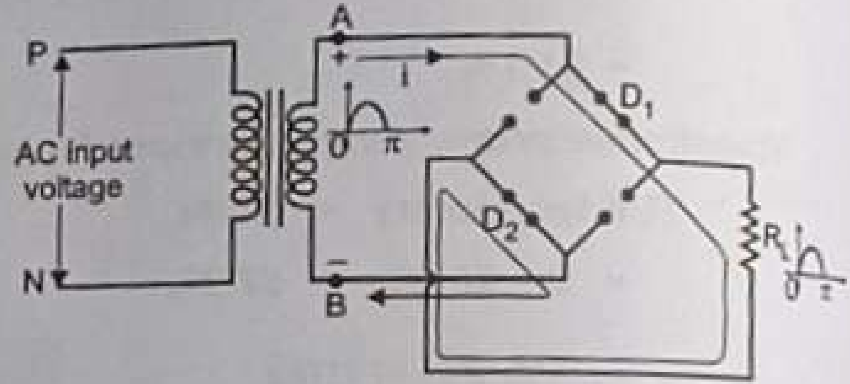

Figure 5.23

During negative half cycle of the input voltage, the terminal 'B' is positive with respect to terminal 'A'. Thus diodes D_3 and D_4 are forward biased and diodes D_1 and D_2 reverse biased . The current path is $B - D_3 - R_L - D_4 - A$. It is shown in figure 5.24. The entire negative input voltage is applied across the load. During positive and negative half cycle, the output voltage and output current is always positive (i..e., unidirectional).

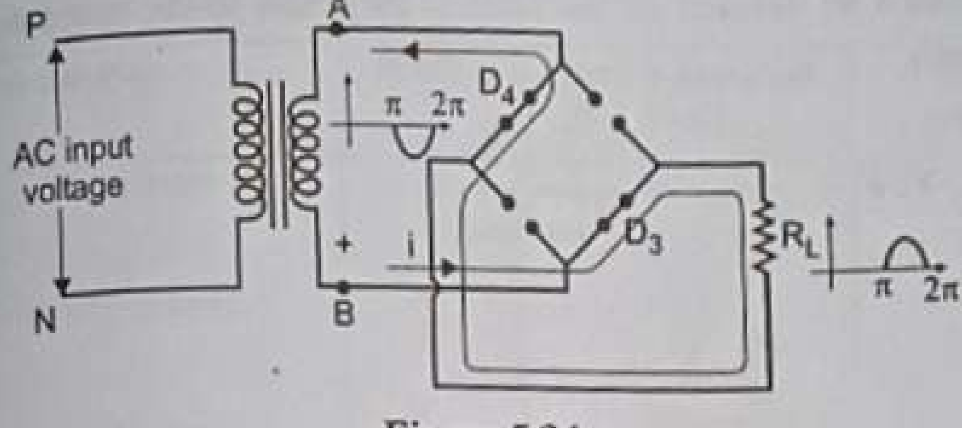

Figure 5.24

The input and output waveforms are shown in figure 5.25.

The waveform of the load current is essentially the same as in the case of full wave rectifier. The ripple frequency of the output is twice that of the fundamental frequency. The derivations for bridge rectifiers are same as that of centre tapped FWR, except TUF.

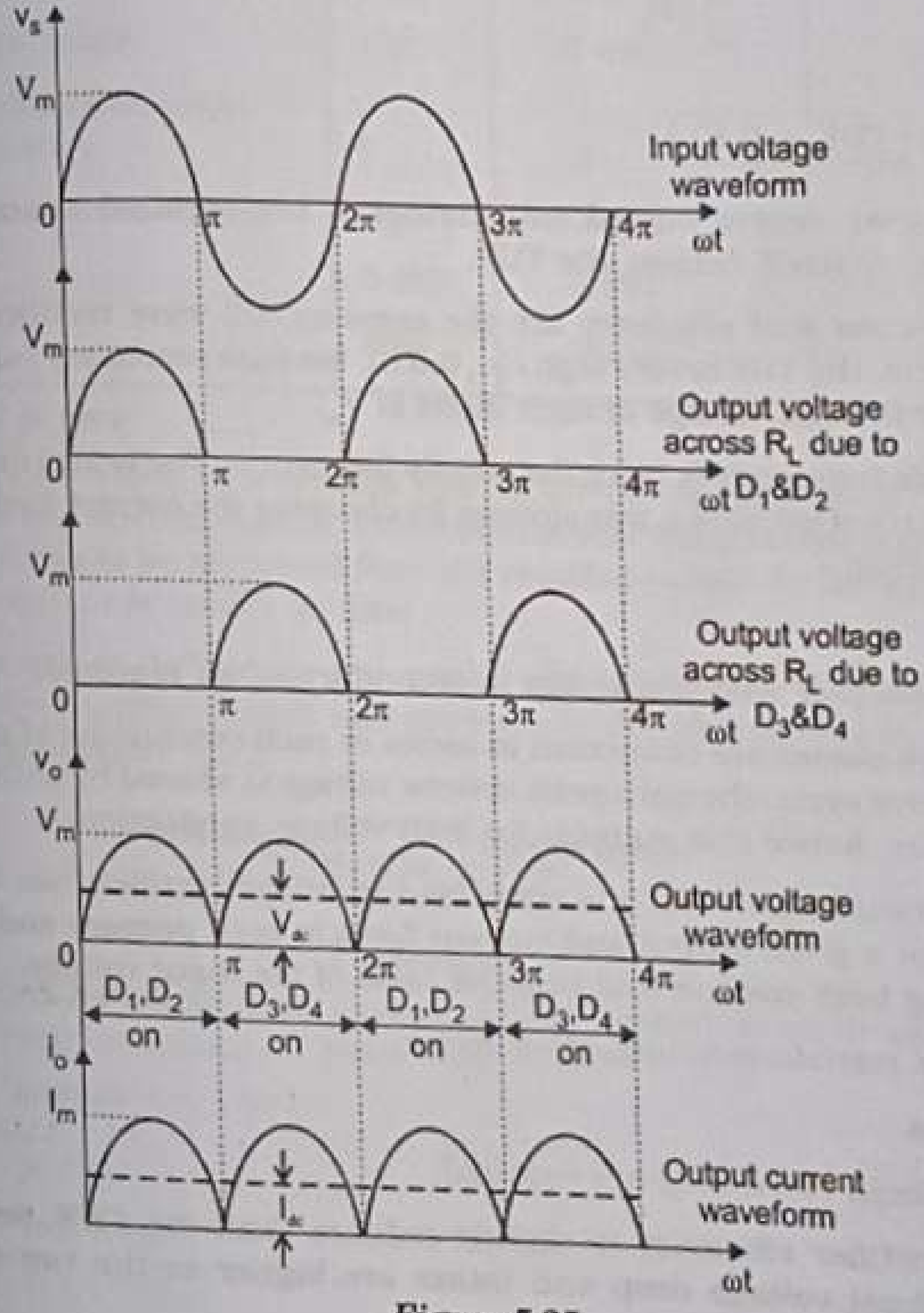

Figure 5.25